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EMISSION ANALYSIS OF A DI DIESEL ENGINE FUELLED WITH BIODIESEL FROM WASTE TALLOW

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Original Article

ABSTRACT

In the current investigation ,an effort has been made to make use of tallow oil for biodiesel production. Tallow oil is non- edible oil and now considered as an alternate form of energy. The tallow biodiesel blends B10, B20, and B100 were used to study the emission characteristics of the fuel. The testing is done for different engine loads 50 and 80%, and the results are compared with neat diesel. In addition to the tallow blends, the nanofluid pentanol is added to the blends to increase the combustion and to reduce the emission of all toxic gases. The temperature of 60°C is maintained for processing the tallow. The transesterification process is carried out to convert the oil to biodiesel with recommended fuel properties. It is observed by employing, B100 the emission of carbon monoxide, hydrocarbon, and smoke opacity are reduced to 22, 32 and 36% respectively. On the other hand, the NOx emission is increased. The pentanol is future added to the blends to reduce the emission all gases particularly NOx. On the whole, it is concluded that tallow is a promising source of energy with lesser emission than diesel. This biodiesel is recommended when they mixed with nanofluids like pentanol.

KEYWORDS: Tallow oil, Emission, Transesterification process & NOx

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INTRODUCTION

Biodiesel produced from the fats of animals and plants gained importance due to its better exhaust emission properties. As the oil is draining the search of an alternate renewable source is very important, hence a lot of research is directed towards biodiesel. Production of biodiesel is the changeling, which is universally and environmentally accepted [1]. The animal fats promise as a better biodiesel due to its cetane number, viscosity, volatility and combustion parameters[2]. The animal fats have achieve the better feet recently in terms of all emission parameters owing to the presence of triglycerides. The emission characteristics of the biodiesel are less due to the higher oxygen content than conventional diesel fuel[3]. In recent days, the use of animal fats for feeding is declined due to the changing food habits of people. Hence it can be used for producing the biodiesel at a cheap cost. The emission studies are carried out for biodiesel in a multi -cylinder, four stroke engine and compared with neat diesel to measure hydrocarbons (HC), carbon monoxide (CO), carbon dioxide CO_2), oxides of nitrogen (NOx) and smoke.

MATERIAL AND METHODS

The tallow waste was collected for slaughterhouse from the Chennai city. The tallow is heated up to 60 ^{0}C to remove the unwanted waxy materials and residues present in the animal fats. After the removal of unwanted waste, they are filtered, decanted and stored in a container to avoid oxidation. Acid and base method is used to process the fats by transesterification. The sulfuric acid catalyst is mixed with the fats and mixed well by a mechanical stirrer. The tallow and methanol is heated for a period of time after shaking. The by product glycerol separates from the mixture. The oil extracted from the tallow is washed with warm water and the biodiesel yield is estimated [6]. Base- catalyzed process also carried out using KOH and methanol. The melted tallow and the KOH dissolved methanol are mixed together and stirred continuously for 3 hours and then washed with water to remove excess amounts of methanol and the glycerol is separated [7]

Table 1: Properties of Fuel

Properties	Diesel	B20	B100
Density (kg/m3)	840	860	853
Cetane number	52	50	
Low heating value (KJ/kg)	43390	39940	40420
Flash point (ºC)	65	65-115	68
Viscosity Pa s (40 ºC)	1.9 - 4.1 $\times 10^{-4}$	5.2$\times 10^{-4}$	4.4 $\times 10^{-4}$

The acid and base pattern used to yield the biodiesel from tallow by transesterification process. The yielded properties of methyl ester are measured and evaluated according to ISO standards like ISO660, 3657 and 6884 respectively table 1. Gas chromatography used to determine the fatty acid compositions. The content of carbon, nitrogen, and sulfur present in biodiesel was also found using CHNS analyzer.

Engine Test Setup

The fuel samples are tested for emission values on a four stroke water cooled CI engine. The specification of the engine is tabulated in table 2. The biodiesel and the diesel fuel are tested at different speeds and engine load. Dynamometer used to vary the engine for different loads. The specific fuel consumption system is positioned to measure the intake of fuel and the content of the air. The exit geometry of the exhaust pipe is modified, changed to elliptical exit since Manigandan at al. has reported elliptical jet produces better mixing efficiency than a circular jet. AVL gas analyzer used to measure the gases like HC, CO, and NOx.

Table 2: Test Engine Setup

No of Cylinder	Single Cylinder
Make	**Kirloskar**
Bore (mm)	110
Stroke (mm)	87.5
Capacity (cc)	661.5
Rated power (KW)	4.4
Compression ratio	17.5:1
Rated speed (rpm)	1500

The exhaust manifold is made of Kevlar composite. Kevlar fiber is taken for its soaring strength and small weight. The exit geometry of the exhaust manifold pipe nozzle is modified based on the literature [11, 12, 13, and 16]

RESULTS AND DISCUSSIONS

The series of experiments were conducted on a four stroke, single cylinder at the different engine speed of 0 to 2000 rpm at the respective brake power 0kW, 1kW, 2kW, 3kW and 4kW. The emission characteristics of the fuel are measured at advanced injection timing.

Hydrocarbon Emission

The HC emission of biodiesel and the diesel fuels are presented in the figure. From the figure, the emission of HC is lesser at low engine rpm. When the engine load is increased, the emission of HC increases due to the high percentage of unburned gases. From the figure 1, it is perceptible that, the emission of B100 produces lesser levels of HC than other tested fuels. B100 perform better in emission test due to its lower viscosity and density.

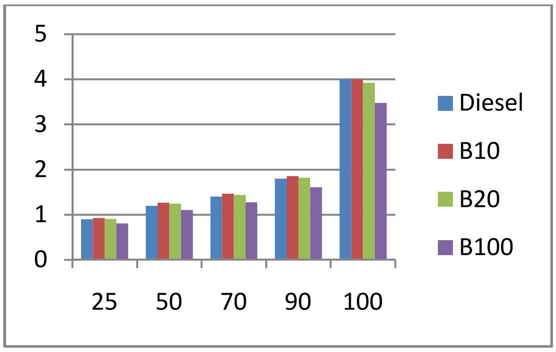

Figure 1: Variation of Hydrocarbon Emission

The emission of B100 emits nearly 35% less hydrocarbon content which is required. The other tested fuels also emit lesser amount of HC emission than diesel.

Carbon Monoxide

The CO emission variation of testing fuels is plotted in the figure 2. The experiments recorded lesser emission of gas carbon monoxide for all engine rpm. From the figure it is understandable that, B100 emit the lesser amount of CO gas than other tested fuels. The observed value of CO emission is lower for all tested fuels compared to diesel, which is appreciable. As the rpm of the engine elevated, the level of CO emission increased due to the lower content of oxygen. B100 generates 10 -15% less emission than diesel. Corresponding to the B100 other fuels also produce a contented value of CO for except diesel.

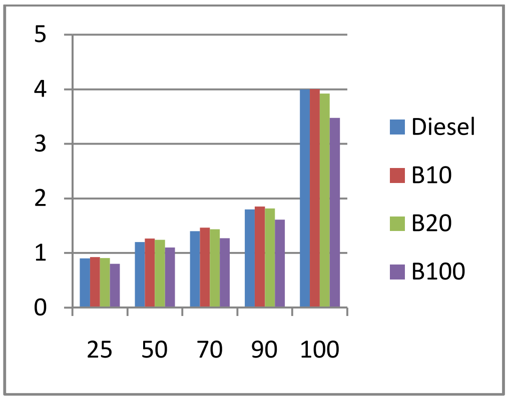

Figure 2: Variation of Carbon monoxide Emission

Oxides of Nitrogen

NOx emission presented in figure 3. At the lower engine load, the percentage of NOx emission is low. As the rpm of the engine rose the emission of NOx is increased, due to the unburned gases.

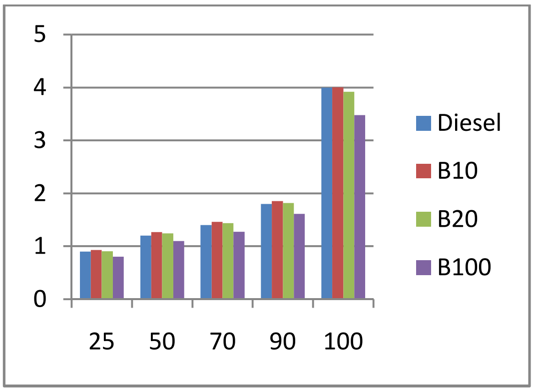

Figure 3: Variation of Oxides of Nitrogen Emission

From the figure, it is clear that the emission of B100 produces less NOx compared to neat biodiesel. Diesel and B10 perform poorly in emission due to the viscosity and injection timings. The emission of B100 produces nearly 20% less nitrogen oxide content which is appreciable. Similar to the B100 other fuels B10 and B20 also produce less NOx content compared to diesel.

Smoke

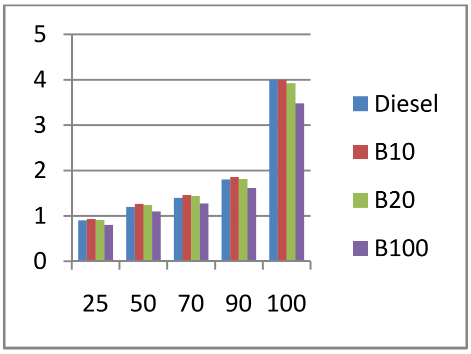

Figure 4: Variation of Soot Emission

The smoke emission of diesel was measured using the gas analyzer. The results are represented in figure 4. The generation of soot is low when the engine running at 1000 rpm. As the engine load is increased the emission of the smoke is high. The emission of B100 has produced less smoke compared to other tested fuels. This feat is achieved by the B100 due to its high heat release rate and lower viscosity. The fuel B100 contains higher oxygen content than other fuels; thereby B100 achieves reducing the smoke emissions.

Effect of Exit Geomertry

The exhaust pipe used to emit the toxic gases like CO, HC, and NOx to the atmosphere which is emitted by the engine. These toxic gases are treated using catalytic converters to decrease the magnitude of poison gas. In addition to the emission, this paper also investigates the effect of exit geometry of the exhaust pipe. The exit of the exhaust manifold modified to an elliptical shape. The elliptical exit achieves bigger compared to a circular outlet. The elliptical jet produces

4% less emission than circular exit. Previous studies claim elliptical nozzle provides higher performance than circular nozzle [11, 12, 13, 16]. The exhaust pipe is made distinct layers of Kevlar fiber. Introduction of the Kevlar in exhaust pipe helps to reduce the noise and the weight of the system. The Kevlar is used due to its better mechanical properties [8, 9, 10, 14, 15, 17, 18 and 19]

CONCLUSIONS

The waste tallow is chosen as the biodiesel. The transesterification process is used to take out the glycerin present in the tallow. The fuels were tested in multicylinder engines at 2000 rpm. The biodiesel is tested to evaluate the emission characteristics of all the fuels. The B100 registers the lesser emission of the CO, HC, NOx, and smoke due to the enhanced combustion process. The oxygen content present in the B100 reduces the amount of unburned exhaust gas. It concluded that B100 biodiesel can be used as a successful alternative fuel in diesel engines with 20% reduced emission. Further, it has been proved that the emission also depends on the geometry of an exhaust pipe. Modifying the exhaust geometry reduces the emission up to 4%.

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